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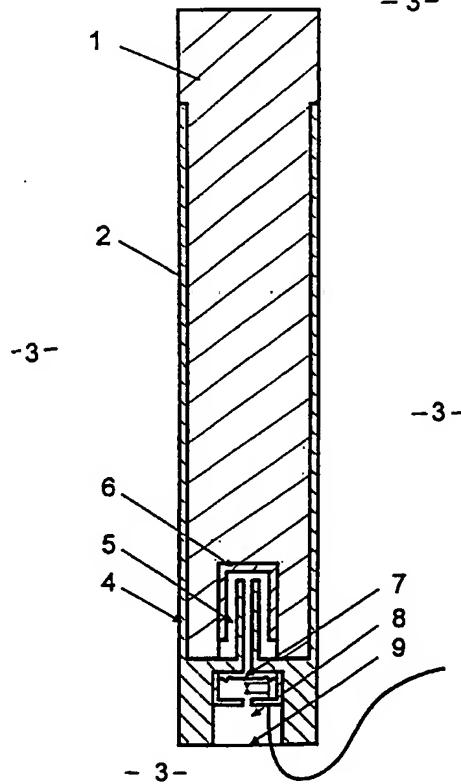
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G01N 19/10, 27/10, 33/24 (75) Inventor/Applicant (for US only): HUTCHINSON,  
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(54) Title: MOISTURE DETECTION



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(57) Abstract: A method of detecting moisture within an unsaturated permeable medium is disclosed which includes detecting a change in air pressure in a cavity within a body of porous material in hydraulic contact with the permeable medium. Also disclosed is a detection assembly for detecting moisture within an unsaturated permeable medium (3), the assembly including a body of porous material (1) adapted to make hydraulic contact with the permeable medium; a cavity (5) within the body of porous material, and detection means (7) for detecting a change in air pressure in the cavity.



IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

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**"MOISTURE DETECTION"****Technical Field**

This invention relates to moisture detection.

5 As used herein the expression "moisture" is to be given a broad meaning and refers to fluids, particularly water, in a porous medium and/or the solutes contained therein.

10 The invention has particular but not exclusive application to agricultural methods and apparatus for detecting when adequate irrigation has been applied to the soil and for illustrative purposes reference will be made to such application. However it will be appreciated that the invention may be utilised in other applications which involve the detection of moisture.

**Background of Invention**

15 Moisture detection methods and equipment of the above type are the subject of copending applications and patents in the names of the present applicant filed under International application PCT/AU98/00128.

**Summary of Invention**

20 The present invention aims to provide an alternative to known moisture detection methods and equipment of the above type.

This invention in one aspect resides broadly in a method of detecting moisture within an unsaturated permeable medium, the method including:-

25 detecting a change in air pressure in a cavity within a body of porous material in hydraulic contact with the permeable medium.

As used herein the expression "body of porous material" is to be given a broad meaning and is not limited to being a cohesive or integral body of porous material. The expression includes loose particulate material.

30 The change of air pressure is preferably generated by the advance of a saturated wetting front through the body of porous material.

In another aspect this invention resides broadly in a detection assembly for detecting moisture within an unsaturated permeable medium, the assembly including:-

a body of porous material adapted to make hydraulic contact with the permeable medium;

a cavity within the body of porous material, and

detection means for detecting a change in air pressure in the cavity.

5 It is preferred that the detection assembly includes:-

an impermeable container containing the body of porous material and having an opening at which the porous material can make hydraulic contact with the permeable medium.

It is also preferred that the impermeable container is a tube or the like 10 vertically positionable in use and open at the upper end and closed at the lower end.

It is also preferred that the cavity in the body of porous material is formed within a chamber in hydraulic contact with the body of porous material.

It is also preferred that the detection means is a pressure sensitive switch 15 having a predetermined set point.

It is also preferred that the set point is a predetermined portion of the vertical height of the porous material expressed as the equivalent height of water.

In another aspect this invention resides in a method of irrigating a crop 20 planted in a planting medium, the method including:-

locating in the planting medium in hydraulic contact therewith a body of porous material having a cavity therein;

detecting a change in air pressure in the cavity;

generating a signal upon detecting the change in pressure, and

25 ceasing irrigation in response to generation of the signal.

In another aspect this invention resides in a method of delaying irrigation in accordance with rainfall, the method including:-

locating in a medium to be irrigated in hydraulic contact therewith a body of porous material having a cavity therein;

30 detecting the presence of rainfall in the medium by detecting a change in air pressure in the cavity, and

controlling the irrigation in accordance with detection of rainfall.

### Description of Drawings

In order that this invention may be more easily understood and put into practical effect, reference will now be made to the accompanying drawings which illustrate a preferred embodiment of the invention, wherein:-

5 FIG 1 is a schematic cross-sectional elevation illustrating the moisture detector of the present invention.

### Description of Preferred Embodiment of Invention

As can be seen in FIG 1, the moisture detector consists of a body 1 of  
10 porous material confined within an impermeable tube 2 which is open at the upper end at which the body of porous material 1 is in hydraulic contact with the soil 3. Tube 2 is closed at the lower end 4. An air-filled cavity 5 is formed in the porous material 1 by means of an inverted cylinder or cup 6 closed at its upper end and open at its lower end. The air in cavity 5 is in hydraulic contact with the  
15 body of porous material.

The material for the porous body is preferably a porous ceramic with a pore size of 50 microns. In this case the moisture switch is "wet" when the ambient soil tension is wetter than -2 kPa and "dry" when the soil tension is drier than -6 kPa. Other pore sizes are also possible, e.g. a pore size of 10 microns  
20 which produces a "wet" point of -10 kPa and a "dry" point of -30 kPa.

The diameter of the porous body is not believed to be critical. A suitable diameter is 20 mm and the length of the porous body is suitably 20 cm. Tube 2 is suitably made from a plastics material.

A differential pressure sensitive switch 7 is connected between cavity 5  
25 and chamber 8. A fine mesh screen 9 separates chamber 8 from the soil 3 that allows the free exchange of air between the cavity and the soil. Changes in pressure in cavity 5 are detected whereby switch 7 operates to switch or control a function, such as for example the making or breaking of a circuit to commence or cease an activity such as crop irrigation. The set point of pressure switch 7 is  
30 selected to be a proportion of the vertical length of the porous material 1 expressed as the equivalent height of water.

In use, when the body of porous material 1 is dry, the pores are filled with air at atmospheric pressure and in this condition the pressure within cavity 5 is

atmospheric and pressure switch 7 is in the normal state. When the soil surrounding the top of the detector becomes wet and the soil moisture is wetter than the water entry pressure of the body of porous material 1, the pores near the top of the porous material become saturated, a saturated wetting front 5 propagates some distance into tube 2, the air ahead of the wetting front is forced to move towards the base of tube 2 and the pressure of air entrapped in cavity 5 rises. This increase in pressure is detected and switch 7 is activated.

When the ambient soil dries to a soil tension less than the air entry pressure of the porous material 1, the porous material is no longer saturated 10 and the air pressure in cavity 5 returns to atmospheric pressure and the switch de-activates and returns to the normal state.

In an embodiment not illustrated, the switch at the lower end of the tube can be covered by a pointed cap or shield such that the whole assembly can be driven into soil by a hammer or the like.

15 It will be appreciated that the moisture detection in accordance with the present invention has a number of advantages over that described in our International application PCT/AU98/00128.

The detector of our earlier application is physically larger than that of the present invention and consequently a larger hole must be made in the soil 20 during installation. This disturbance of the soil alters the hydraulic properties of the soil above the funnel and gives rise to a measurement of wetting front position which may differ from that in the undisturbed soil. The funnel of our earlier application is therefore limited to applications where soil disturbance is relatively unimportant such as when the soil is cultivated, or in applications 25 where the soil some distance above the funnel can be made impervious to movement of the wetting front. Being of smaller size, the detector of the present invention does not have these disadvantages to the same extent.

Furthermore, the detector of our earlier application required the wetting front to propagate to the base of the funnel before being detected. Thus the 30 funnel detector of our earlier application is generally unable to detect a wetting front closer than 10cm from the soil surface and is limited in practical application to use with relatively deeply rooted vegetation. On the other hand, the detector

of the present invention detects a wetting front as soon as the front reaches the top of the detector.

The detector of our earlier application is operable, in one sense only in a single mode, ie it can only turn off irrigation when a wetting front is detected, 5 whereas the detector of the present invention is able to both turn off irrigation on detection of a wetting front and then turn the irrigation back on when the soil tension surrounding the detector is less than the air entry pressure of the porous material and the pressure in the detector reverts to atmospheric pressure.

It will of course be realised that whilst the above has been given by way 10 of an illustrative example of this invention, all such and other modifications and variations hereto, as would be apparent to persons skilled in the art, are deemed to fall within the broad scope and ambit of this invention as is herein set forth.

**Claims**

1. A method of detecting moisture within an unsaturated permeable medium, said method including:-
  - 5 detecting a change in air pressure in a cavity within a body of porous material in hydraulic contact with the permeable medium.
  - 10 2. A method of detecting moisture as claimed in claim 1, wherein said change of air pressure is generated by the advance of a saturated wetting front through said body of porous material.
  - 15 3. A detection assembly for detecting moisture within an unsaturated permeable medium, said assembly including:-
    - a body of porous material adapted to make hydraulic contact with the permeable medium;
    - 1 a cavity within said body of porous material, and
    - 2 detection means for detecting a change in air pressure in said cavity.
  - 20 4. A detection assembly as claimed in claim 3, and including:-
    - 1 an impermeable container containing said body of porous material and having an opening at which the porous material can make hydraulic contact with the permeable medium.
  - 25 5. A detection assembly as claimed in claim 4, wherein said impermeable container is a tube or the like vertically positionable in use and open at the upper end and closed at the lower end.
  - 30 6. A detection assembly as claimed in claim 3, wherein said cavity in said body of porous material is formed within a chamber in hydraulic contact with the body of porous material.
  7. A detection assembly as claimed in claim 3, wherein said detection means is a pressure sensitive switch having a predetermined set point.

8. A detection assembly as claimed in claim 3, wherein said set point is a predetermined portion of the vertical height of said porous material expressed as the equivalent height of water.

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9. A method of irrigating a crop planted in a planting medium, said method including:-

locating in said planting medium in hydraulic contact therewith a body of porous material having a cavity therein;

10 detecting a change in air pressure in said cavity;

generating a signal upon detecting said change in air pressure, and

ceasing irrigation in response to generation of said signal.

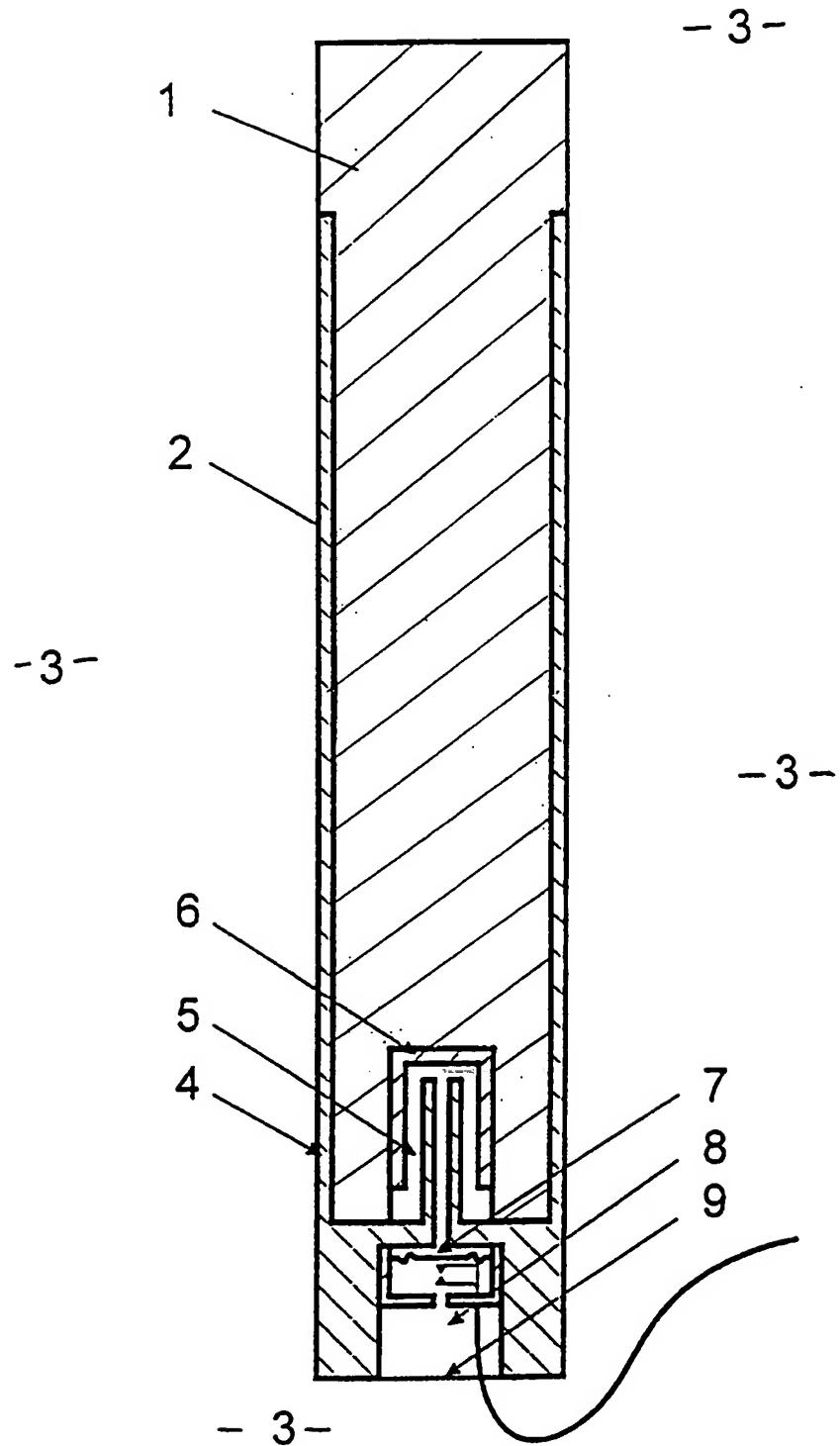
15 10. A method of delaying irrigation in accordance with rainfall, said method including:-

locating in a medium to be irrigated in hydraulic contact therewith a body of porous material having a cavity therein;

detecting the presence of rainfall in the medium by detecting a change in air pressure in said cavity, and

20 controlling the irrigation in accordance with detection of rainfall.

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FIG 1

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU00/01498

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
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According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols)		
IPC: A01G 25/16, G01N 19/10, 27/10, 33/24		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
AU: IPC AS ABOVE		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
DWPI: IPC as above and (MOIST+ and WATER) and (PORO+ or PERMEAB+)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5156179 A (PETERSON et al) 20 October 1992 See figures	1-10
X	GB 2130375 A (SLOPE INDICATOR CO) 31 May 1984 See figures	1-10
X	NL 8300364 A (VAN DE ROTTEN) 16 August 1984 See figures	1-10
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 1 February 2001	Date of mailing of the international search report 9 February 2001	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer N. STOJADINOVIC Telephone No : (02) 6283	

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU00/01498

<b>C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
X	US 4520657 A (MARTHALER) 4 June 1985 See figures	1-10
X	WO 8604212 A1 (IPACO) 31 July 1986 See figures	1-10
X	AU 31846/93 A (MORNINGSIDE HOLDINGS et al) 22 July 1993 See figures	1-10

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/AU00/01498**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
AU	31864/93	US	5329081				
WO	8604212	EP	245246				
US	4520657		NONE				
NL	8300364/83		NONE				
GB	2130375	CA	1195526	JP	59150319	US	4517842
US	5156179	AU	26520/92	EP	608277	IL	103260
		WO	9305644				
END OF ANNEX							